

DIRECT INJURY AND SURVIVAL OF JUVENILE CHINOOK SALMON PASSING THROUGH THE REMOVABLE SPILLWAY WEIR (RSW) AT LOWER MONUMENTAL DAM, 2008

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ABSTRACT

Direct passage survival and condition of hatchery HI-Z tagged juvenile (112 mm mean total length) Chinook salmon, *Oncorhynchus tshawytscha*, were assessed at Lower Monumental Dam in March 2008. The primary objective was to determine the condition (survival and injury rates) of fish after passage through Spillbay 8, equipped with a Removable Spillway Weir (RSW), and identify any injury problems associated with RSW passage. The fish were released so their projected path (Computational Fluid Dynamic Analysis) took them 1.5 ft (deep) and 6.5 ft (mid) above the crest of the RSW. A sufficient number of fish were released to detect a 5% difference at $P = 0.05$ in survival and injury estimates between the mid and deep passage locations. The recapture rate (physical retrieval of alive and dead fish) was 95.6% and 97.8% for deep and mid-passed fish. All control fish were recaptured.

Four metrics were utilized to evaluate effects of spillbay passage on fish: (1) direct survival (1 and 48 h), (2) malady-free, (3) conditional probability of fish being malady-free given alive at 48 h, and (4) joint probability of 48 h survival and being malady-free. Maladies included visible injuries, scale loss ($\geq 20\%$ per side), and loss of equilibrium. The use of these metrics was helpful in pointing out fish condition issues associated with deep-released fish and possible mechanisms.

The survival ($P = 0.027$) and malady ($P < 0.01$) estimates for deep-released fish were significantly lower than for mid-released fish. The 48 h survival probabilities were 0.971 (SE = 0.010) and 0.930 (SE = 0.011) for mid and deep-passed fish, respectively. The malady-free probabilities for the mid and deep-passed fish were 0.990 (SE = 0.012) and 0.883 (SE = 0.017), respectively. The conditional probabilities of being malady-free given alive at 48 h were 0.997 (SE = 0.010) for mid passage and 0.905 (SE = 0.016) for deep passage location. The joint probability of 48 h survival and being malady-free estimates were 0.970 (SE = 0.014) and 0.842 (SE = 0.018) for the mid and deep-passed fish.

The entrainment depth also affected injury types and rates. Injury rates were higher (12.8%) for deep-passed fish than for mid-released fish (2.2%). The most prevalent injury was eye damage (hemorrhages, bulged eyes, and/or ruptured pupils) followed by bruises to the head or body. The probable mechanism of injury was primarily shear related.

The higher malady rates for deep-passed fish may be partially due to the steepness of the angle (45°) where fish encounter the flow deflector and/or the transition where the RSW outflow meets the spillbay chute may break up the laminar flow over the RSW enough to cause some of the

deeper passing fish to contact the spillbay chute exposing them to potentially harmful conditions on the chute surface and near the flow deflector. As recorded by Sensor Fish, the number of severe hydraulic events was about three times higher for the deep (1.52 events/release) than for the mid (0.57 events/release) passage routes.

In summary, fish passing near the RSW crest encountered a less benign exit route than those passing higher (within 6.5 ft) in the water column. Further evaluation incorporating vertical fish distribution near the RSW crest may be prudent to estimate the overall impact of this passage route on the fish.